

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Toru SUZUKI et al.

Serial No. 09/854,528

Filed May 15, 2001



Confirmation No. 8224

Docket No. 00653/01-F-011US/NT

Group Art Unit 1731

Examiner Christopher Fiorilla

ORIENTED SINTERED CERAMIC  
PRODUCT AND MANUFACTURING  
METHOD THEREOF

RECEIVED

NOV 26 2003

16-1700

DECLARATION UNDER 37 CFR 1.132

We, Toru Suzuki and Yoshio Sakka, the inventors named in the above-identified application, hereby declare as follows:

1. The co-authors named in the reference (HEISEI 12 SPRING MEETING, page 98) applied by the Examiner in the Office Action of May 19, 2003 are Toru Suzuki, Hideyuki Ohtuka, Yoshio Sakka, Keijiro Hiraga and Koichi Kitazawa, as apparent from the attached copy of page 98 of the reference and the attached English translation thereof.

2. Hideyuki Ohtuka, Keijiro Hiraga and Koichi Kitazawa served only as advisors to us in connection with the work reflected in this reference, and were working under our direct supervision.

3. Neither Hideyuki Ohtuka nor Keijiro Hiraga nor Koichi Kitazawa is a co-inventor of the subject matter described in this reference.

4. We further declare that all statements made herein of our own knowledge are true, and that all statements on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States

Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Toru Suzuki  
Toru Suzuki

November 12, 2003  
Date

Yoshio Sakka  
Yoshio Sakka

November 12, 2003  
Date

## 強磁場中スリップキャストによるアルミナの配向

(金属材料技術研究所) ○鶴木 道、大冢 美幸、三輪 圭地、平賀 孝二  
(東京大学) 北澤 云一

[はじめに] セラミックスの作製プロセスの一つであるニロイドプロセスは粒子を液体中に分散し、それから固化成形する方法であり、粒子を速的に分散し高密度に成形するのに有効である。このプロセスに微粒子を用いることで、より微細な構造を得るセラミックスの作成が行われている。一方、近年の過渡電子マグネットの発達により液体ヘリウムを使用せずに強磁場(10T程度)を比較的簡単に得られるようになってきており、非磁性物質にも外部から及ぼされる無視できないエネルギーとして強磁場を作用させることができるようになってきた。一般に六方晶系の結晶構造では、 $\langle 110 \rangle$ 方向と $\langle 111 \rangle$ 軸垂直方向(底面)とで磁気異方性を示す。アルミナは六方晶系の結晶構造を有するが、非磁性物質で結晶軸が各系に小さいためその磁気異方性は従来は無視できるものとしておわれてきた。しかし、強磁場を用いる事でこの磁気異方性が無視できない量にまで大きくなるとしたら、拘束力を外界から印加する事によりアルミナの結晶軸が可逆になるのではないかと期待できる。そこで、本研究では粒子が多く分散して流动性の良いサスペンションを作成し、強磁場下でスリップキャストを行なうことで磁場が配向したアルミナを作成することを試みた。

[方法] 原料アルミナとして粒径 0.4μm(住友化学 A3-03)の粒状微粉末と 0.2μm(大明化学 TM-DAR)の粒状微粉末を用いた。水系サスペンションにそれぞれの粉末を分散させるため、超音波で 10 分搅拌を行ない、さらにスターーラーで 12h 以上搅拌した。サスペンション中で粒子を均一に分散させる方法として、高分子電解質(東亜合成 アニン A-6114)を粒子表面に接着させその電離による静電反発力と高分子そのものによる立体障壁を利用する方法を用いた。このサスペンションを固化成形するためのスリップキャストを 10T の強磁場下で行ない、アルミナの結晶軸を強制的に変化させた。その後、400Mhzでの CIR 加温と 1400~1600℃での焼成を行なった。アルミナの配向を XRD により測定し、FE-SEM、光学顕微鏡での組織観察を行なった。

[結果] スリップキャストした時の正面と平行な面を T 面、裏面を S 面とした。右図には 1600℃で焼成した試料の T 面と S 面の XRD 指紋を示す。強場印加方向に因に示したようにスリップキャスト方向と平行である。T 面では六方晶系の C 面と C 面と平行な(006)面の強度が非常に強く、また平行に近い(104)、(1010)面の強度が強く見れている。一方、S 面では T 面と平行な(110)、(300)面の回折強度が強くなっている。これらは六方晶の C 面が強場印加方向と平行に配向している事を示している。図 2 に示すように 1600℃焼成炉ではあいアスペクト比をもつ板状結晶が強場印加方向と垂直面に配向していた。これらのことから強磁場下でのスリップキャストで一軸方向に配向したアルミナの形成が可能である事が明らかになった。

すずき とおろ、おおつか ひでゆき、さとう よしお、ひらが けいじろう、きたざわ こういち

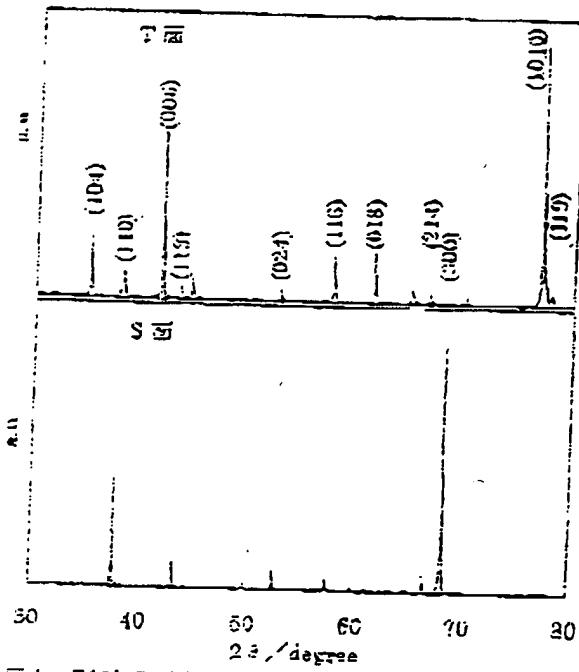


図 1. 強場印加平行面と垂直面の XRD 測定結果

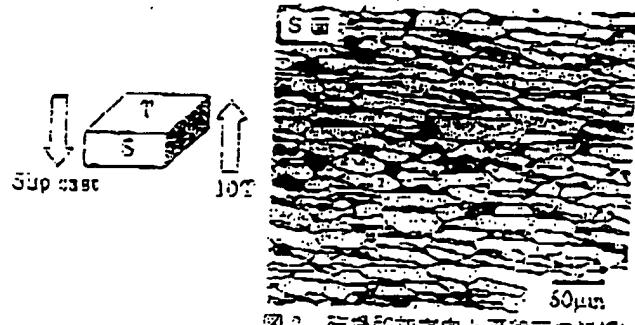


図 2. 強場印加方向と平行面の組織

## 4 - 1 4 A

### Orientation of Alumina by Slip Casting in Ferromagnetic Field

(National Research Institute for Metals) Toru SUZUKI,

Hideyuki OHTUKA, Yoshio SAKKA, Keijiro HIRAGA

(Tokyo University) Koichi KITAZAWA

#### [Introduction]

A colloid process which is one of the processes for the manufacture of ceramics is a method where particles are dispersed in liquid, solidified and molded therefrom and it is effective for finely dispersing the particles and for molding them in a high density. Production of ceramics having finer structure has been carried out using fine particles for this process. On the other hand, as a result of the development of superconducting magnets in recent years, a ferromagnetic field (about 10 T) has been able to be achieved relatively easily without the use of liquid helium and it has been possible to apply a ferromagnetic field as a non-negligible energy which is applicable from outside even to a non-magnetic substance. Generally speaking, a hexagonal crystal structure shows a crystal magnetic anisotropy in the direction of c-axis and in the vertical direction to the c-axis (bottom). Although alumina has a hexagonal crystal structure, it is a non-magnetic substance and has a very little magnetic susceptibility whereby its magnetic anisotropy has been considered to be negligible. However, if the crystal magnetic anisotropy becomes too much

t neglect by the use of a ferromagnetic field, it is expected that a tissue control of alumina becomes possible by applying a ferromagnetic field from outside. Under such circumstances, it has been attempted to produce alumina wherein the crystals are oriented by preparing a suspension having a good fluidity where the particles are well dispersed followed by subjecting to a slip casting in a ferromagnetic field.

#### (Methods)

With regard to the starting alumina, granular fine powder having a particle size of 0.4  $\mu\text{m}$  (AA-03; Sumitomo Chemical) and granular fine powder having a particle size of 0.2  $\mu\text{m}$  (TM-DAR; Daimei Kagaku) were used. In order to disperse each of the powder materials into an aqueous suspension, stirring was carried out by means of ultrasonic wave for 10 minutes and then further carried out for not shorter than 12 hours using a stirrer. As to a method for dispersing the particles in the suspension in a stable manner, there was used a method in which a high-molecular electrolyte (Aron A-6114; Toa Gosei) was adsorbed on the surface of the particles whereby an electrostatic repulsion by its electrolysis and a steric hindrance of the high-molecular substance itself were utilized. A slip casting for the solidification and the molding of this suspension was carried out in a ferromagnetic field of 10 T whereby a tissue control of alumina was attempted. After that, a CIP treatment

at 400 MPa and a sintering at 1400-1600°C were carried out. Orientation of alumina was measured by an XRD and observation of the tissue was carried out by an FE-SEM and an optical microscope.

#### [Results]

A plane which was parallel to the bottom and that which was vertical thereto after the slip casting were called plane T and plane S, respectively. In the drawing on the right, results of an XRD for the planes T and S of the sample sintered at 1600°C are shown. The direction of application of a magnetic field is parallel to the slip casting direction as shown in the drawing. In the plane T, intensities of the plane C of the hexagonal system and the plane (006) parallel to the plane C were very strong while intensities of the planes (104) and (1010) nearly parallel thereto were strong. On the other hand, in the plane S, the diffraction intensities of planes (110) and (300) parallel to the c-axis were strong. Those indicate that the c-axis of hexagonal system is oriented in parallel to the direction of application of the magnetic field. As shown in Fig. 2, in a product sintered at 1600°C, a plate-like tissue having a high aspect ratio developed in a direction which was vertical to the direction of application of the magnetic field. From those, it is clear that production of alumina oriented in a uniaxial direction is possible by a slip casting in a ferr magnetic field.

**Fig. 1      Result of an XRD Measurement of the Parallel and  
Vertical Planes to the Direction of Application of Magnetic  
Field to Sintered Substance**

(upper chart)      Plane T

(lower chart)      Plane S

**Fig. 2      Tissue of the Parallel Plane to the Direction of  
Application of Magnetic Field**

Plane S